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Research Paper

# Introduced Grey Squirrels subvert supplementary feeding of suburban wild birds

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ABSTRACT

Providing food for wild birds is perhaps the most widespread intentional interaction between people and wildlife. In the UK, almost half of households feed wild birds, often as peanuts and seed supplied in hanging feeders. Such food is also taken by the introduced, invasive Grey Squirrel *Sciurus carolinensis*. Little is known of how Grey Squirrels utilise this resource and how they affect feeder use by wild birds. To assess this we recorded the numbers and time spent by animals visiting experimental feeding stations in suburban gardens, and also asked if exclusionary guards (to prevent Grey Squirrel access), food type (peanut, mixed seed), habitat and weather conditions influenced visits. Using automated cameras, we recorded 24,825 bird and 8577 Grey Squirrel visits. On average > 44% of the time feeders were utilised, they were being visited by Grey Squirrels. Grey Squirrel presence prevented birds from feeding at the same time (> 99.99%). Feeders where Grey Squirrels were dominant were less likely to be visited by birds, even in their absence. Guards reduced Grey Squirrel use to a minimum on seed feeders, and by approximately half on peanut feeders. Squirrels, food type, guard status, habitat and rainfall all influenced bird activity and timing of feeder visits. Our work suggests that Grey Squirrels reduce the availability of supplementary food to wild birds, while gaining large volumes of food resources with corresponding benefits. Given the ubiquity of supplementary feeding, it is likely that this is an important resource for urban Grey Squirrels; feeder guards mitigate this effect.

## 1. Introduction

Globally, over half of people live in urban areas (UN, 2011), rising to over 80% of national populations in countries such as the UK and USA (UNPFA, 2007). Urban areas are extremely altered, novel ecosystems, where native species face challenges and opportunities unlike any other. For birds urban ecosystems can be a place to exploit for urban adapters (Evans, Chamberlain, Hatchwell, Gregory, & Gaston, 2011; Kark, Iwaniuk, Schalimtzek, & Banker, 2007), in part due to the very high volumes of supplementary food provided by human residents. Conversely, urban ecosystems can be challenging, as urban areas have exceptionally high densities of predators, such as the domestic cat (*Felis catus*) (Thomas, Fellowes, & Baker, 2012), and introduced competitor/predator species such as the Eastern Grey Squirrel (*Sciurus carolinensis*; hereafter the Grey Squirrel) (Bonnington, Gaston, & Evans, 2014b, 2014c). Understanding the interplay between such factors and bird abundance and diversity must be an important link in our efforts to build opportunities for bird conservation in our towns and cities (Davies et al., 2009; Orros & Fellowes, 2015).

Urban areas generally, and in particular the surrounding suburban areas, hold large populations of many bird species (Bland, Tully, & Greenwood, 2004; Cannon, Chamberlain, Toms, Hatchwell, & Gaston, 2005), and for some species suburbia provides a refuge for declining populations (e.g. the UK Red listed Song Thrush (*Turdus philomelos*); Gregory & Baillie, 1998). Garden bird feeding is perhaps the most important way for people to engage with wildlife in many parts of the world (Cox & Gaston, 2016). Some 48% of households in Britain (Davies et al., 2009) and 53 million households in the USA feed wild birds (US Fish, 2014), providing an enormous and highly localized additional food resource (Orros & Fellowes, 2015).

Suburban feeding stations typically provide supplementary food for seed-eating and omnivorous passerines (Cannon et al., 2005; Chamberlain et al., 2005; Lepczyk, Mertig, & Liu, 2004). In the UK, the most common supplementary food types provided (i.e. non-table scraps) are peanuts and mixed seed, each typically provided in specialist feeders (Orros & Fellowes, 2015). Positive associations between supplementary feeding, breeding population size and reproductive success have been documented (Fuller, Warren, Armsworth, Barbosa, &

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Gaston, 2008; Robb et al., 2008), although this is not always so (Harrison et al., 2010; Plummer, Bearhop, Leech, Chamberlain, & Blount, 2013). Indeed, recent work in both the UK and North America suggests that supplementary feeding during the breeding season may increase local nest predation (Hanmer, Thomas, & Fellowes, 2017a; Malpass, Rodewald, & Matthews, 2017). Some species may also benefit more than others due to the suitability of food provided and relative competitive ability and adaptability of some species (Evans, Newson, & Gaston, 2009; Evans et al., 2011). Therefore, supplementary feeding may be directly and indirectly affecting the structure of urban bird communities (Galbraith, Beggs, Jones, & Stanley, 2015).

Despite the enormous influence of supplementary food on the ecology of urban birds, we have little understanding of how this resource may be utilised by non-target species, and the consequential effects on the species the resource is intended to support. In the UK, the most visible mammal at supplementary feeding stations is the Grey Squirrel. Grey Squirrels were deliberately introduced into Great Britain on several occasions between 1876 and 1929 and elsewhere in Europe during the 20th century (Bertolino, Lurz, Sanderson, & Rushton, 2008). In Britain, the Grey Squirrel is common in urban areas (Baker & Harris, 2007; Bonnington et al., 2014c), and is spreading rapidly from introductions in other parts of Europe (Bertolino et al., 2008). Grey Squirrels are considered to be a significant conservation threat, particularly to the native Red Squirrel (*Sciurus vulgaris*) (Bertolino, di Montezemolo, Preatoni, Wauters, & Martinoli, 2014). Grey Squirrels carry disease (squirrelpox, Bruemmer et al., 2010; *Borrelia burgdorferi*, the agent of Lyme disease, Millins et al., 2015, 2016), and cause economic losses in forestry (Mayle & Broome, 2013). In the context of this work, evidence suggests that urban Grey Squirrel population size and density is associated with the provision of supplementary food in gardens (Bowers & Breland, 1996; Parker & Nilon, 2008) and there is some evidence that they can competitively exclude birds at supplementary feeders (Bonnington, Gaston, & Evans, 2014a; Hewson, Fuller, Mayle, & Smith, 2004). Bonnington et al. (2014a) used taxidermied Grey Squirrels on feeders, and showed that resource use by birds was reduced by 98% in the presence of a mounted animal. However, we have no quantitative data on how the presence of live Grey Squirrels affects feeder usage by garden birds, nor how much of the food provided is taken by the squirrels. This is crucial, as the Grey Squirrel is both a competitor for supplementary resources and a nest predator, and so may locally directly and indirectly affect the breeding success of some native bird populations (Bonnington et al., 2014b; Hanmer et al., 2017a; Newson, Leech, Hewson, Crick, & Grice, 2010).

Furthermore, a highly conservative estimate suggests that enough supplementary food is provided in the UK (Orros & Fellowes, 2015) to support a Grey Squirrel population around four times the estimated 2.5 million individuals found in the country (Battersby, 2005). What is not understood is how much supplementary food is actually taken by Grey Squirrels. It is thought that Grey Squirrels typically spend considerable periods of time using supplementary feeders (Pratt, 1987), but no published study to our knowledge has attempted to quantify this experimentally using live wild animals over a prolonged period or considered how this affects feeder use by different urban bird species.

Nevertheless, while data are lacking, both purchasers and manufacturers of feeding stations have recognised that Grey Squirrels may be consuming food intended for birds, so specialised feeders and feeder guards are produced to counter this. Typically, standard feeders are surrounded by guards to prevent access by squirrels and other large species such as corvids and invasive parakeets (Antonov & Atanasova, 2003; Sorace & Gustin, 2009). Such guards should decrease the food taken by Grey Squirrels and thus their negative impact on supplementary feeder usage by target birds (Bonnington et al., 2014a; Hanmer et al., 2017a). Furthermore, if the presence of Grey Squirrels reduces resource intake rates by birds (Bonnington et al., 2014a), we may expect to see a behavioural response to their presence. We speculate that excluded species may respond to high levels of Grey Squirrel presence by altering the timing of their visits to established supplementary feeding stations, thus extending foraging opportunities or utilising alternative food sources.

We have little understanding of how providing food may be unintentionally affecting the very species people wish to support due to the use of feeding stations by non-target species, such the invasive Grey Squirrel. Here, we report the results of a manipulative field experiment in suburban gardens using live birds and Grey Squirrels for the first time. The objectives were to investigate a) how Grey Squirrel presence affected the rate and timing of feeder use by garden birds, and whether this interaction was altered b) by the type of food resource provided (peanuts or mixed seed) or c) the presence of a feeder guard. Furthermore, we examine how these overall patterns of feeder utilisation were influenced by d) local (urban) habitat or e) weather conditions.

## 2. Methods

### 2.1. Study area

This study was conducted in the suburbs of the large urban district centred on Reading, South East England. Greater Reading covers approximately 72 km$^2$ and has a population of ~290,000 people (Office for National Statistics, 2013). The eastern suburbs of Lower Earley and Woodley where fieldwork was carried out have human populations of 32,000 and 35,470 individuals respectively.

### 2.2. Individual site selection

To represent typical suburban residential areas in the southern UK, twenty study areas of predominately detached/semi-detached houses at least 500 m apart and > 100 m away from any patches of natural or public urban green space (such as parks and playing fields) were selected. One volunteer participant who already fed birds regularly using bird feeders was recruited in each of the 20 areas. Areas selected were broadly similar in terms of local habitat availability, with housing densities of ~10 households/ha and 30–50% constructed surfaces, with garden sizes of 100–200 m$^2$.

### 2.3. Study design

Experimental work was carried out between 4 September and 30 November 2014. A paired peanut and two port seed feeder (CJ Wildlife small defender feeders, Shrewsbury, UK) on the same feeder stand was placed in each of the 20 volunteer back gardens. Food supplied was the Hi-Energy No Mess Seed Mix (c.550 calories per 100 g) and Premium Whole Peanuts (c.560 calories per 100 g) from CJ Wildlife (Shrewsbury UK). Feeding stations were placed ca. 2 m clear from garden boundaries and vegetation cover, and the feeders were within 0.5 m of each other at least 10 days before the start of data recording to allow animals to discover them. Ten gardens received a wire cage guarded (using individual CJ Wildlife small feeder guardian cages) pair of feeders to exclude Grey Squirrels and other large animals (locally these are primarily Eurasian Magpies (*Pica pica*), Western Jackdaws (*Corvus monedula*) and Great Spotted Woodpeckers (*Dendrocopos major*)) and ten received a pair of identical but unguarded feeders. No other feeders or artificial food sources were present in the study gardens during this period. Feeders may have been present in adjacent gardens, but all were at least 20 m distant and were believed to be similar across the sites. Feeder visitors were recorded using an infra-red motion triggered camera trap (Ltl Acorn 5310; Ltl Acorn Inc, Wisconsin, USA) which could record visits to both feeders at the same time. The camera was set to record 10 s video clips with a one minute gap between each recording to maximise memory and battery life. The lag time between triggering movement and the camera recording was 0.6 s. Feeders were refilled up to twice a week depending on need, to ensure that feeders